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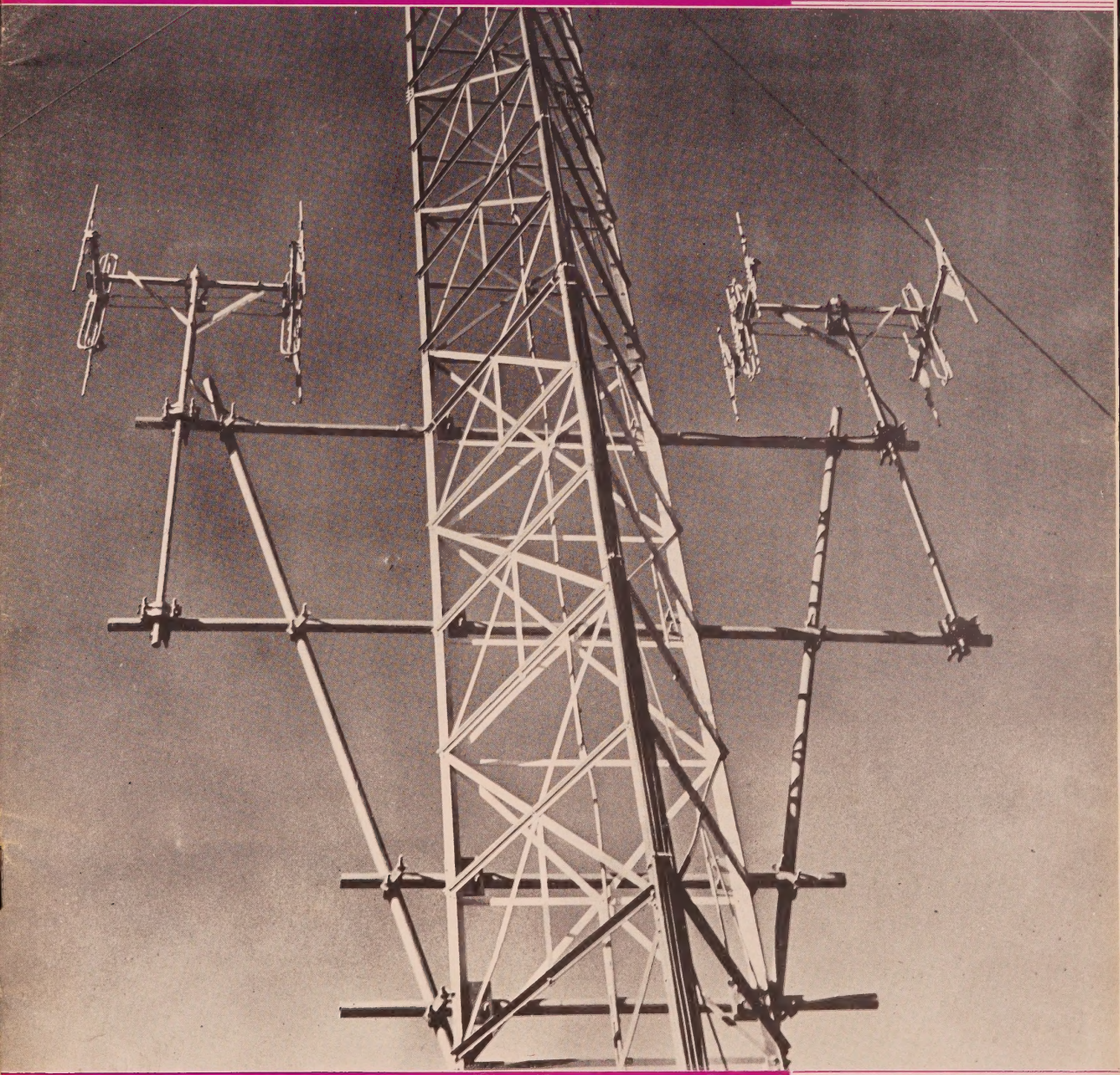

In this issue . . .

REPORT ON PAN AMERICAN
PIPE LINE COMPANY'S MICROWAVE SYSTEM
AFTER THREE YEARS OF OPERATION

D. E. Noble

SUN SPOTS

We have been enjoying a moratorium on skywave interference in the 30-50 Mc band for some time, and we can look forward to a gradual and unrelenting increase in ionospheric refraction as we approach the next peak of the sun spot cycle. Newcomers in the mobile radio art may look with complacency upon the excellent communications that have been enjoyed with systems operating in the 30-50 Mc band, but those of us who were active in mobile radio during the past sun spot maximum remember the disastrous effects of the sporadic E and F_2 layer refractions. Car-to-car communications across the country was commonplace during the period of sun spot disturbances, and interference was experienced by every 30-50 Mc system in operation in the country. I remember one power utility radio system where the normal radius of operation was cut down to approximately one mile by continuous interference from a South American station operating on the same frequency. The only solution to this problem was a shift in frequency.

In our past frequency-committee work, we considered the advisability of using staggered patterns and area assignments to minimize skywave interference. Perhaps we should revive our interest in protective assignments and consider the advantages to be derived from the use of a split channel pattern based upon an anti-skywave configuration.

The sun spot minimum will be reached in 1955, and from that time on, there will be a steady increase in sun spots until the maximum occurs in 1960. Presumably we shall have a few more years of comparative freedom from skywave interference, but the long trek through the sun spot maximum will seem endless to those experiencing the interference.

Vibrators for Power

Vibrator power supplies have given a good account of themselves over the years. Motorola is a pioneer in the application of vibrators to mobile receiver power supplies. The first vibrator-powered broadcast receivers for cars were developed for the justly famous Motorola car radio. Later, in 1938 and '39, Motorola pioneered a mobile transmitter in the 30-40 Mc band, with a vibrator power supply. Now there is an overwhelming trend toward the use of vibrator power supplies in mobile transmitters rated at 30 Watts and under. The high efficiency of operation, the high degree of reliability, and the ease of servicing are the important factors which have established the popularity of vibrator power supplies for transmitters.

Here at Motorola, we are very proud of our 6/12 V. line of mobile communications equipment. It was the full flowering of more than fifteen years of experience with vibrator transmitter power supplies which made possible the development of this unique design which provides such efficient, reliable and versatile operation. In testing the units in my car, I have concluded that there has never been a finer piece of mobile communications equipment, or one which offers such a sound engineering solution to the many operational and maintenance problems. Testing the units in my car gave me quite a thrill, and I hope you will be as enthusiastic about our 6/12 line as I am.

Transistors

By the way, transistors are coming closer. Our research group in the Motorola Research Laboratory, Phoenix, Arizona, is producing transistors which perform consistently without degradation at temperatures above 90° C ambient. This temperature range is adequate for mobile communications equipment. So far, the usual grown and diffused junction triodes have been limited in frequency response so that the use of gains beyond approximately 450 Kc have not been practical. The comparatively new surface barrier type transistor, which makes use of tenths of thousandths thin germanium sections, is showing fine performance characteristics even above 80 Mc.

With the temperature and the frequency problems under control, the use of transistors in radio equipment becomes feasible. The accumulation of a history of successful field experience, the development of uniform transistor characteristics, and an extensive exploration of aging and failure patterns, are essential before equipment should be released for operation in the safety service mobile field. Reliability of equipment is essential and the approach should be conservative. Transistorized equipment should be released only when there is assurance that the reliability will exceed the reliability expected with equivalent tube equipment. When that should be, is anybody's guess—and I find the guesses ranging widely, all the way from one year to five years. I thought you might like to know that there are transistors in your future and, while they will not provide better quality communication in terms of intelligibility or range, they will provide improved reliability and reduced current drain. There is no inherent reason why the life of a perfectly designed transistor should be limited. The problem is to duplicate the perfect design consistently in production; and the progress made in the past six months has been substantial.

Eventually, transistors will cost less than tubes. The result of the low cost will be the application of transistors to broadcast car and home receivers and to television receivers. Initially the applications will be directed to equipment where reliability, power drain, or size reduction is important, but watch the applications spread when the price drops below tube level.

There is nothing to be gained by rushing transistors into the mobile field before full maturity is achieved in both transistor design and circuit development, but I can assure you that the hopes of the past few years are certainties for the years to come.

Dan Noble

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Radio Antennas on top of Casper Mountain in Wyoming. Story on pages 10 and 11.

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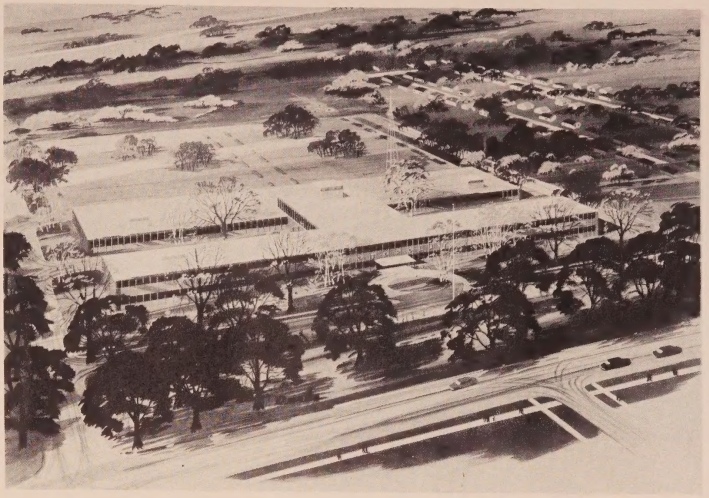


Plan Campus Headquarters

Excavation is scheduled to start this spring for a 200,000 square-foot engineering building on a 40-acre tract Motorola has bought on Chicago's northwest side.

The site in Niles, Ill., will ultimately be developed into a campus headquarters containing the company's administrative office and engineering laboratories.

President Paul V. Galvin calls the move part of a long-term policy of decentralization. "The company's decision to build at this time is an expression of confidence in the immediate future of the electronics industry."

The Niles campus figures prominently in Motorola's realignment of various operations to achieve greater efficiency and permit further orderly growth. The site is convenient to most of the company's office and engineering personnel.

More than $5,000,000 will be invested in the Niles headquarters when it is completed. Plans call for extensive landscaping and off-the-street parking. No manufacturing facilities will be located on the Niles campus.

Glimpse Into The Future

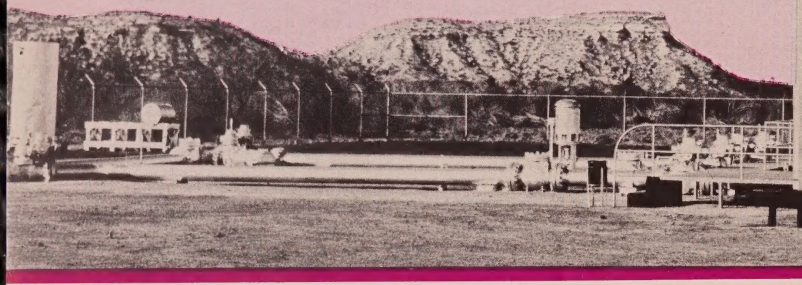
Two recent talks by Daniel E. Noble, vice president of Motorola's Communications & Electronics Division, lifted the curtain on advances to come in the communications industry.

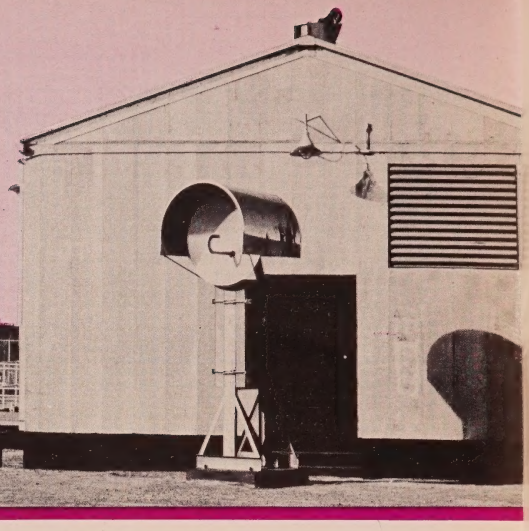
Noble spoke in Dallas, Texas, at the annual conference of the Petroleum Industry Electrical Association on the role of communication in automation. He also speculated on the future possibilities of tropospheric "forward scattering", and of transistors in low-drain mobile receivers.

Noble's second talk was at the fifth annual Electronic Components Symposium in Washington, D. C., on the subject of equipment reliability. Emphasis was on new advancements in the electronics art at the three-day meeting co-sponsored by the Institute of Radio Engineers, American Institute of Electrical Engineers, Radio-Electronics-Television Manufacturers Association, Department of Defense and National Bureau of Standards.

Tornado Tests . . .

MICROWAVE RELIABILITY





Three years of dependable service through good weather and bad are indicative of a long productive life for Pan American Pipe Line Company's microwave system.

The same tornado that jarred San Angelo, Texas, during May of 1953, paid a call on the Carlsbad microwave station of the Pan American Pipe Line system on its way into town. It wasn't a very friendly call. The tower top was left swaying erratically through a six foot arc. All the steel support cables were ripped three or four feet through the guy clamps. A whole section of the REA power line serving the area was torn out and a half mile length of it was found tightly wound around the twisted tower. The sun meter that controls the tower warning lights, mounted 30 feet up the mast, was thoroughly smashed and a large rock was found inside. The sheet metal building that housed most of the electronic equipment was tilted precariously. The outdoor housing for the microwave frequency circuits was dented and pitted, apparently by stones and pebbles flung against it by the high winds. Despite the damage, the microwave station never went completely out of operation.

Throughout the night, the operators pushed their messages through as the tower top passed through the center of its arc. In the morning, a crew of men straightened the tower by tightening the guy cables one at a time until it was pulled back into shape. The half mile of power cable was unwound, the sun meter was replaced and the building was tipped back in place and reshaped. The microwave system operated just as it had before the storm.

THE SYSTEM

Although the microwave system is made up of a number of electronic circuits which require careful adjustment, its basic simplicity provides the ruggedness demonstrated at the Carlsbad station. The Pan American system is the spine of a communications network through which all the pipe line activities are coordinated. Frequent or prolonged failure would be prohibitively costly.

A radio carrier of extremely high frequency, approximately 6700 megacycles, is beamed across the gaps between the towers. Radio waves at these frequencies have characteristics similar to those of light waves. They travel in a straight line and can be concentrated in a narrow beam much like the beam of a flashlight. Consequently, the radio signals are not disseminated over the countryside, but are contained within a private wireless circuit.

On the carrier, Pan American superimposes six separate voice signals in individual subcarrier channels. By adding a few small components, at the desired stations, the pipe line company could increase the capacity to twelve voice channels. And by using later versions of the same relatively inexpensive units, the capacity of the system could be increased to 24 voice channels if future conditions warranted the expansion.

THE RECORD

Probably the most important feature of the microwave system from the user's viewpoint is its dependability. Fortunately, tornados do not hit the microwave stations often enough for the survival of the Carlsbad station to be cited as typical of the dependability Pan American has come to expect of its communications circuit. However, the record is spectacular enough. During the eighteen months preceding March 1st, 1953, the system was operating 99.8% of the time. The system was actually out of service for

only nine hours during the eighteen months, or 0.2% of the time. Only 3 short duration subcarrier outages occurred over this period affecting only part of a single channel causing partial failure for an additional 3.9%. And this typical record of 95.9% perfect total system operation was established without emergency standby equipment.

During the three years since its installation, the microwave system, designed by Motorola, has become an indispensable link between the necessarily widespread offices and stations concerned with operation of the pipe line. In addition to handling a heavy load of routine messages, the system is always available for emergencies. The VHF stations are strategically placed along the microwave system and elsewhere so that the pipe line area is thoroughly blanketed. All company cars and trucks are equipped with VHF units so that key personnel can be reached immediately when an emergency occurs.

Two men each maintain half of the microwave system. They both devote about a day a week to microwave and spend the rest of their time working on the other electrical equipment in use on the pipe line, including the VHF equipment.

The low cost of maintenance is perhaps the second most rewarding feature of the system. Pan American, on the basis of three years experience, has broken down the monthly cost of operating its system in the following manner:

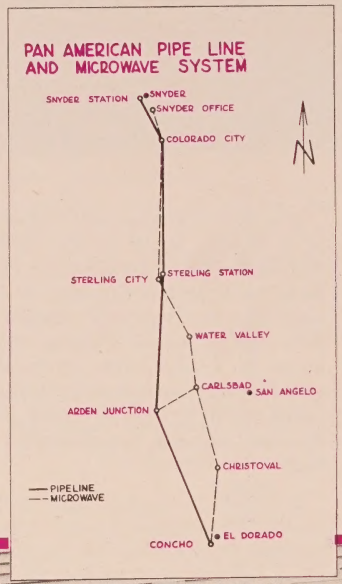
Salaries and transportation expense for fieldmen	$451.00
Power (Average $20 per station)	160.00
Tube cost	37.50
Component parts cost	10.00
Tower upkeep	3.50
Tower light cost	2.00
Total	$664.00

This total reduces to a cost of $4.75 per system mile per month or a cost of $0.95 per circuit mile per month, an extremely low cost for any type of communications equipment.

The Pan American Microwave System was installed by employees of the Pan American Pipe Line Company with engineering assistance provided by Motorola in initially lining up the circuits and setting the various signal levels. More engineering assistance was provided later by Motorola in making minor modifications, but the most recent additions to the system were made entirely by the personnel of the Pan American Pipe Line Company.

THE PIONEER

Its three year old system makes Pan American one of the pioneers in the application of microwave, yet the company has encountered none of the hardships normally associated with pioneering. Since its installation, the system has provided dependable service at low cost. As time goes on, this service seems to improve. Often a month or two passes between repairs. When the system was originally laid out, space was allotted at each station for the standard standby equipment. Performance has so far exceeded expectations that the company now considers additional expense for standby units unjustifiable. The visionaries who, a few years back, foresaw the eventual replacement of extended communications lines by microwave were apparently practical men after all.



Deliveryman S. W. Frisby at the Concho station calls the Snyder office 142 miles away over a private microwave circuit.

A Revolution in the Backwoods

Modern Communications Tool Helps Bring Benefits of Present Day Life To The Kentucky Highlands

The days of finding a Lil Abner or a Snuffy Smith in the back hills of Kentucky are almost over. New roads, electrical power, two-way radio and energetic missionaries are gradually helping the people to change their out-dated ways. True, you can still observe evidences of a primitive way of life, but they are fast disappearing.

Much of the responsibility and credit for nurturing the transition rightfully belongs to the mighty efforts of the Red Bird Mission of the United Brethren Church. One of the biggest obstacles they have faced was communications among their eight centers, each located in a remote and isolated part of the Red Bird area. To help them solve their communications problem, they borrowed an idea from industry and installed Motorola two-way radio.

Radio is the only possible means of communication for the same reason that this section of the country has long remained backward. And that is topography.

Statistically, less than one-half of one percent of the land is flat including creek beds. The section is characterized by steep, timber-covered mountain slopes with fast moving creeks running in the narrow valleys.

The greater majority of the people are peace loving farmers eking out their existence from cornfields perched on the sides of the mountains. Strange as it may seem, the area is greatly overpopulated. There are two principal reasons why the people remain.

The scenic beauty of the timber covered mountains exerts a strong attraction for some, while the rest are content to live there simply because their forebearers did.

The educational, medical and religious benefits of modern life have by-passed the area largely because it is on "yon side" of the Kentucky Ridge Mountains and the Pine Mountain Range, away from the five counties of which it is a part.

However, in spite of all the obstacles, the Red Bird Mission has succeeded in bringing many of these benefits to the people. They have established a hospital and high school boarding school at Beverly which is also headquarters of the missionary effort. At the outlying mission centers are primary schools and medical care stations under the charge of registered nurses. One of the mission centers maintains a demonstration farm where new and improved farming methods suitable to the conditions of the land are illustrated for the benefit of the Red Bird area farmers. In addition, of course, are the chapels which much resemble, in character and construction, those one would normally find in small up-to-date villages.

It is a land of many contrasts with modern cobblestone homes being erected next to 200 year old "dwellings"; a woman washing the family laundry in a creek a hundred yards from another woman doing hers in a modern automatic washer; mail delivered to post offices by mule back while modern two-way radios whip messages back and forth between

mission centers with the speed of light.

Being able to call the only doctor in the area who is stationed at the mission hospital in Beverly "on the Motorola" has gone a long way toward solving many of the medical problems of the people. Consultations between the nurses stationed at the outlying mission centers and the doctor are frequent.

Thanks to the aid of the Federal Communications Commission in realizing the desperate plight of the missions without communication and therefore granting them a Special Emergency radio license, the medical and educational phases of the mission operation have been greatly helped. Where previously the nurses at the centers outside of Beverly worked without the direct advice of the doctor and often had to send patients on a long tortuous trip to the hospital, now care of the patients is under the direct supervision of the doctor, although by remote control, thus eliminating many unnecessary trips to the hospital. Too, the doctor may now be hurriedly summoned in an emergency where previously the patient had to be hand-carried to the hospital on a litter.

The Rev. Mr. G. R. Klinefelter who is the Greasy Fork Center preacher and the associated primary school teacher while his wife, a registered nurse, takes care of the medical needs of the people in the area, is quite enthusiastic about the use of the radio. "More than ever," he maintains, "we are able to help the people of this long neglected section because each of the mission centers, although isolated by nature, is in direct radio contact with the mission headquarters, hospital and school at Beverly and with each other. This means that we don't have to wait a week or more for the mail to bring us advice and instructions. Times of the year when travel to and from the Greasy Fork Center is impossible, 'the Motorola' is literally our lifeline because it can mean the difference between life and death for the sick. I know how we managed without the radio and that makes us value the use of it very highly."

School bell and radio system antenna exemplify the contrast between the old and the new evident everywhere as the Red Bird Mission hastens the transition to a modern way of life.

Miss Squire, secretary to Mission Superintendent John Gischoff, takes a call over two-way radio remote control consolette on her desk at Mission headquarters.

Heavy bulldozers snake the logs
from forest clearing to the nearest pond
to await the spring thaw. Later the timber will
float down rivers and lakes all the way to the mills.
Two-way radio co-ordinates these far-flung woodland operations.

"RADIO-CONTROLLED" WOODLANDS

Flying over northern Maine, the traveler sees acres of timberland, streams and waterfalls but hardly a trace of the camps, trucks, towboats and men that keep pulpwood moving in a steady stream from forest to the paper mills.

The co-ordination essential to movement of the wood goes almost unnoticed. Yet, until well after World War II, lack of communication to the deep woods often resulted in time-wasting delays.

EXTENSIVE EMPIRE

Today two-way FM radio is providing the dependable control necessary for maintaining the steady stream of pulpwood. Since 1949 the Great Northern Paper Company of Bangor, Maine, has emerged as an industry leader in use of two-way radio. Hub of the company's operations is the paper mill in Millinocket. Spokes of the empire extend as far as 175 miles northward into the Maine woods, where Great Northern owns 2,225,000 acres of forest land.

Mother Nature provided the cheap and convenient transportation for bringing the wood to the mills. Northern Maine abounds with vast interconnecting streams, rivers and lakes, and these waterways are utilized to the fullest.

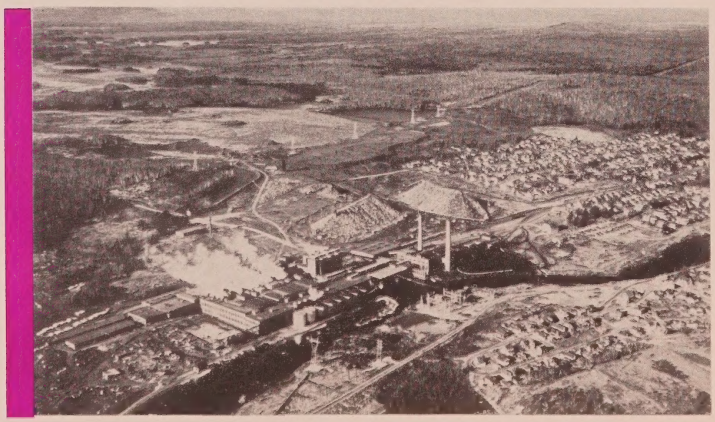
During summer and fall, trees are felled, cut into 4-foot logs and are stacked into piles. Rough roads are bulldozed to the piles, and when winter snows come the logs are loaded onto horse or tractor-drawn sleds and pulled to the frozen ponds. As the ice thaws, the wood floats down rivers and streams to the lakes. At the lakes, it is gathered into "booms," towed to the lake outlets and released to float through more streams to the next lake. This process is repeated over and over until the logs reach the mills.

For efficient handling, only as much pulpwood is released at each point as can be accommodated farther downstream. This calls for close co-ordination among the widely scattered logging camps, boom houses, towboats and mills.

WIDE COVER

After a busy summer, the log stockpiles at the mill may contain up to 90,000 cords of wood ready for use during winter.

Great Northern's two-way radio system ties the whole operation together, from the logging superintendents' vehicles to the towboats, the maintenance shops at Greenville, the Ambajejus boom house, and finally the woodlands operating office at Millinocket.



Vast stockpiles of logs are floated in each summer for use during the winter.

One of Great Northern's radio-equipped towboats guides a boom of 4,000 cords of pulpwood across a Maine lake toward the giant paper mills at Millinocket.

Eleven permanent and eight temporary base stations are spread throughout northern Maine. With 30 additional mobile radio units installed in pickup trucks and towboats, the Great Northern radio network virtually blankets the entire wooded area.

Each major logging camp has its own Motorola base station, where a clerk at the flip of a switch can request information or relay orders to the logging superintendents in the woods. The supervisors thus are freed of having to drive back to the camp for communications; they can operate from miles away by using radio.

CUTS PAPER WORK

Costly downtime of logging machines has been cut drastically. Twenty minutes after a bulldozer broke down on the upper Allagash, the needed repair part was on its way from the Greenville shop 150 miles away. Before radio it would have taken a week for the part order to reach the supply room.

Sometimes the Greenville shop does not stock a needed part. Then supply clerks can quickly check the Millinocket, the St. Francis or Fort Kent offices by radio to locate it. The clerk simply notifies all stations within voice range that he is seeking a certain part. If none has it in stock, each relays the request to more distant points. Chances are excellent that the part will be located within 15 minutes and sent speeding on its way.

The vast paperwork of carrying on pulpwood operations has been greatly reduced with radio. Payrolls, commissary supply orders and weekly cutting reports are all relayed to Millinocket by microphone. Any questionable report can be checked via radio within minutes, instead of days. The main office at Bangor is now right on top of all woodland operations.

The Great Northern radio system is thoroughly economical. To maintain a telephone system over the same area for just one year would cost more than the purchase and maintenance figures for the complete radio network.

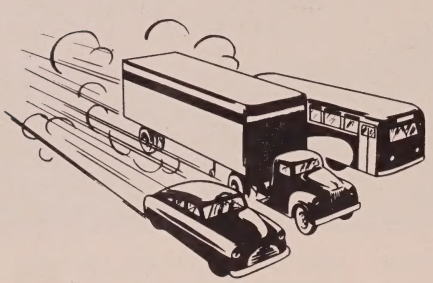
In saving of towboat time alone, the radio more than justifies its existence. Where the captain formerly had to dock his boat, hunt a phone and call Millinocket for orders, now he uses the radio right on his boat for instant communications.

Great Northern's radio also is tied in with the Maine Forest Service's lookout tower 38 miles north of Millinocket. This allows the company to be instantly aware of any forest fires anywhere in the Maine woods.

In such a far-flung logging operation, it is difficult to measure the time and mileage saved by radio. However, the ability to exchange information and co-ordinate activities is extremely useful. As one Great Northern towboat captain puts it, "Not a day goes by that I'm not thankful we have a two-way radio system."

Dispatchers at the mills talk directly to logging supervisors deep in the forest.

STATE-WIDE RADIO NETWORK BLANKETS WYOMING'S HIGHWAYS



Wyoming's Highway Department depends on state-wide Motorola two-way radio system to construct, maintain and police its web of highways.

Five thousand five hundred miles of highway criss-cross Wyoming's 97,500 square mile area and not a one of them is out of reach of the Highway Department's new two-way radio system.

Although the state is not heavily populated, all 5,500 miles of state highways carry a heavy traffic load. Ranches, farms, oil wells and mines are largely dependent on trucks for transportation. Because distances between centers of population are great, people are accustomed to traveling long distances. Vacationists, too, who descend on this scenic state in the summer months, add substantially to the state's traffic.

In Wyoming, the Highway Department is not only responsible for construction and maintenance, but also for performing the functions of a state police organization in enforcing highway laws, checking the tonmileage of trucks, and protecting life and property on the roads.

Both the maintenance and patrol functions are complicated by the terrain, which combines wide plains and rugged mountains, and extremes of high and low temperature, subject to swift changes which may bring icing conditions or heavy snow.

PLANNING

As a preliminary to setting up the new system, the Highway Department sent questionnaires to the highway departments of the 47 other states in the country, asking for 14 points of information ranging from the type of equipment used to methods of financing and control. Answers were received from 45 states, many giving extensive and very helpful information.

The department was especially fortunate in being able to plan a completely new FM system to replace the older and inadequate AM equipment installed in the late 30's. As a result, it was free to take advantage of the newest developments in radio communications and to plan for any future requirements that could be anticipated.

SELECTING SITES

At the time the project was started, engineers considered it important to select the highest locations in the state as sites for the base stations. On that basis, topographic maps showed only a few suitable sites for the main stations, and those were on the higher peaks where there were no access roads. To use those locations meant installing miles of power lines and building new roads.

Instead, Wyoming's engineers selected other moderately high points close to a power line and easily accessible by car. Next, with the cooperation of manufacturers who loaned test transmitters and receivers, radiation

tests were made from each selected site. To make sure that all tests were on the conservative side, 40-ft. towers for example were used for the test antenna where it was planned to eventually install a 100-ft. tower. Where 250-watt stations were planned, 60-watt fixed stations were used in the tests.

Three or four cars were driven over every mile of highway to be served to test reception. Particular attention was given to stretches of highway running through canyons. In several instances contact was possible between points at elevations of 5,000 ft. despite intervening mountains 10,000 to 12,000 ft. high. And in the canyons, the radio waves seemed to travel as if the high walls acted as wave guides.

CROSS-CHANNELS

A unique design feature of the state-wide radio system is cross-channel operation of the mobile units. Most of the mobile radios used by the highway patrol and the highway maintenance department are equipped with two transmitters, one operating on a frequency of 47.22 mc. and the second on 42.82 mc.

The reason for cross-channel operation is to permit mobile-to-mobile communications between patrol cars of the highway patrol and vehicles of the highway maintenance department. Ordinarily each service operates on its own frequency, but the ability to switch to a second channel has many advantages. This is true, especially in winter weather, when patrol cars and maintenance vehicles must work together.

The great distances between centers of population in the state made it important that the county sheriffs' offices and the city police be integrated into the state-wide radio system. To tie in these public safety agencies, the state purchased and maintains mobile equipment for the local law enforcement agencies at a fixed monthly charge per unit except at dispatch stations where the equipment is supplied and maintained without charge by the state in return for operational facilities.

ADDITIONAL SERVICES

The most careful consideration was given in the initial planning to the matter of future expansion. The engineering and construction departments will be included on the maintenance department frequency, and the highway patrol frequency may be made available to the Game and Fish Commission and to the Civil Defense Agency.

Arrangements have been made already to allow pilots to file flight plans over the network wherever CAA facilities are not available to them. Plans for additional public services are being considered as a result of the new experiences in the course of operating the system.

Although only two frequencies are in use for the Highway Department's main stations and mobile transmitters, with 40-kc. channels, the equipment is designed so that, when greater channel utilization is desired, it can be quickly and economically altered for 20-kc. split channel operation.

Left to right: J. R. Bromely, superintendent of the Wyoming Highway Department; John Roberts, chief radio technician and Thurman Sherard, administrative assistant, discuss aspects of the new radio system.

Motorola locally controlled desk-top consoles such as the one shown above are used at all remote control points in the state-wide radio system.

THE LONESOME COWBOY . . .

. . . AIN'T ANYMORE

TWO-WAY RADIO SAVES A LOT OF WEAR AND TEAR ON MEN AND TRUCKS, TIES VARIED OPERATIONS TOGETHER

Tales of the West are full of lone cowhands, solitary horsemen whose only companion was Old Paint and an occasional coyote. They made fortunes for pulp story writers and the movies but, like the stagecoach, they lost out to progress.

The era when a ranch hand was out on his own for days at a stretch is almost over. Today the keynote is co-ordination of effort in a pattern that spells more profit for the ranch operator and a better life for the men.

That newest of effective tools—FM two-way radio—has won its spurs since World War II. The cowhand is simply more valuable when the boss can communicate orders and direct the work at all times, no matter in what remote pasture the hands are working.

Typical of the modern, aggressive ranchers using radio profitably is Field Bohart of Colorado Springs, Colo. Two years ago he installed two-way radio on his 45,000-acre ranch to help cut down on the endless travel he and his men were required to do.

Fortunately, progress had already taken care of one problem—where do you install a radio on a horse? During the last 10 years the four-wheel-drive pickup truck has been nosing out the horse for most of the transportation of feed, tools, material and men on the ranch.

Bohart equipped his three pickups with standard Motorola two-way radios, put a similar unit in his own auto, and even carries a portable "Handie-Talkie" radiophone in his airplane.

WIFE IS DISPATCHER

Base station for the radio system is in the living room of Foreman Jim Tanner's home, with Mrs. Tanner as chief operator. Direct contact can be made instantly with the foreman, the three other ranch hands and the owner, even when the vehicles are as much as 40 miles away from ranch headquarters.

Keeping the long miles of fence, the cattle guards, the windmills and the corrals repaired, together with the routine of checking and caring for 2,000 head of cattle, adds up to a big job for the four-man crew. It is important that all jobs be done as quickly as possible, and this means close co-

Rancher Field Bohart uses portable radiophone to co-ordinate repairs.

Foreman's wife, Mrs. Jim Tanner, relays all radio messages from mobiles through base station in her living room. She is ranch's licensed operator.

Left: When snows are deep, Bohart uses radiophone in private plane to spot isolated cattle and direct ground crews bringing feed. He also has two-way radio in car.

Right: Ranch Foreman Jim Tanner is always in close touch with headquarters. He depends on radio to direct ranch hands to pastures where there's work to do.

ordination of work. Radio makes this possible.

Each day the applications of the radio system are different. Recently one of the men, Joe Cocke, found that he needed one more roll of wire to finish a fence repair. Ranch headquarters where the wire is stored was 15 miles away. He radioed to Mrs. Tanner and asked to have one of the other men drop off the wire if someone was coming that way.

Foreman Jim Tanner had just left the tool shed on his way to check over the animals in a pasture near where Cocke was working. He pressed his microphone button and told Cocke that he would return to the supply shed, pick up the wire and drop it off at the fence job.

Field Bohart, in his car on the highway, heard the exchange of messages and suggested another solution. Bohart had noticed a cattle guard timber which needed replacing near where Cocke was waiting. Bohart suggested that instead of Tanner doubling back to the shed, he should dispatch another man, Harry Weeks, to take the timber and wire out to Cocke. After helping Cocke repair the fence, they could work together on the cattle guard. Mrs. Tanner relayed the instructions to all concerned.

AERIAL SPOTTER

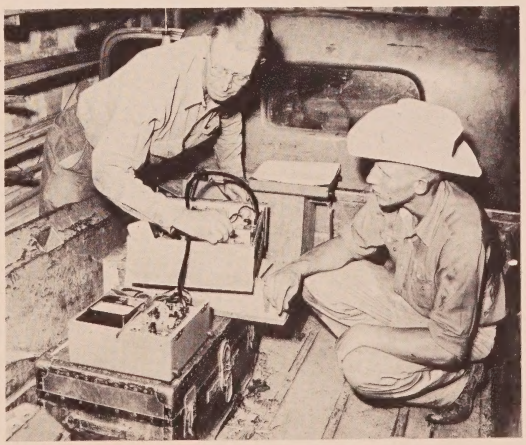
A few hours later Tanner ran into trouble at the herd. One cow was having trouble calving, and Tanner called for assistance. Cocke and Weeks, working nearby, answered his radio appeal and within a few minutes help was at Tanner's side.

During the winter, the cattle require supplementary feed which is delivered via the pickup trucks. Ordinarily, the animals gather in small bunches which are hard to spot. When the snow is deep, Field Bohart uses his private plane to spot the cattle, and he radios their location to the men in the trucks. By actually overseeing the operation and directing the work, Bohart cuts the time required in half.

On the Bohart Ranch, as in so many other businesses, two-way radio has outlived the gadget phase and is now accepted as a very valuable tool. Foreman Jim Tanner puts his views this way:

"The radio sure saves a lot of wear and tear on the men and trucks. We're probably working just as hard as we always have, but now we're getting more done, faster."

Bohart rides the range in a four-wheel-drive pickup truck, successor to the horse in modern ranch operation.



For occasional maintenance and frequency checks, the trucks are taken to a Motorola service station.

MINES STRIKE IT

Two-Way Messages Without Wire Ease Growing Pains in Open Pits

Photo by Kaufmann & Fabry Co.

Open pit mines are a lot like teen-age boys. They keep outgrowing their britches, and their voices are forever changing at the wrong moment.

Nobody wants to stop the mines' growth. But the voice problem can be licked, mine operators are discovering, with two-way radio communication.

Whether the mine yields copper or coal, there's always a need for communication between headquarters and pit vehicles — the shovels, locomotives and trucks. When the mine is small, signaling can be done simply with whistle, bells and telephones. But as stripping continues, the pit outgrows the range of primitive devices, and "spreading the word" becomes a major problem.

Take the case of Kennecott Copper Corporation's Santa Rita mine in New Mexico. There, in the shadow of the ancient Gila cliff dwellings, man has been mining copper for 800 years. Before World War I, Kennecott took over the ancient diggings and began large-scale operations. By 1954 the plant had spread over the open-pit mine and its associated dump area, an underground mine, a precipitating plant, and necessary shops and administrative units. More than 1,000 men are employed in the three-mile-long operation which yields about 50,000 tons of ore and waste daily.

WIRE LINES LOST

As the pit was deepened and widened, problems of communication developed. The whistles had limited range and, with other distracting sounds, often were inaudible to persons on the surface dumps. Whistles can only convey a signal; hence much time was lost in translating whistle sounds into an intelligible message. Telephones installed at the control tower and at switch points were restricted to use by those in the immediate vicinity. Blasting, wind and electrical storms often damaged wire lines, and progress of the benches in the pit necessitated frequent moving of telephone lines and poles.

RICH WITH RADIO

In an effort to overcome the disadvantages of conventional telephone communication, a trolley telephone system was tested in July, 1948. Numerous blind spots developed along the haulageway; contact was lost when the pantograph slipped off the overhead wire, other machines caused electrical interference, and contact with the control tower could not be maintained when the test locomotive was on the waste dump.

Kennecott's management tried another method — short-wave radio. In exhaustive tests, Motorola two-way radios operating in the 152-162 mc. band proved that intercommunication was available at all times at any point in the operational area. Mobility of the sets eliminated much delay in transmitting work orders, making repairs and moving personnel. Disruption of service by weather and blasting conditions became a thing of the past.

In addition to the base station in the control tower, mobile units were installed in eight electric locomotives, a diesel locomotive, a crane and in trucks operated by three pit foremen, general foreman, pit foreman, chief electrician, powder foreman, electrical trouble shooter and track and sample departments.

Later a selective signaling device was added in the locomotives to prevent distraction of the engineers by non-pertinent calls. When the tower operator wants to talk to the locomotives, he presses a call button, signaling the engineer, who then lifts his microphone and automatically switches on his receiver.

Kennecott officials say the two-way radio has resulted in increased production, better morale and more efficient operation. Specifically, the advantages are:

1. Routing of trains and locomotives can be done from the control tower instead of by telephone from the switch points;

2. Shovels can be located immediately when needed at another location;

3. Time-consuming trips out of the pit to obtain assay reports are no longer necessary;

4. Injured employees are assured quicker medical attention after accidents;

5. In case of breakdowns, repairmen and parts are sped to the scene without delay;

6. In blasting, more detailed instructions by radio have reduced the uncertainties and hazards;

7. Foremen can talk with each other at any time and from any point in the area, so as to co-ordinate the work schedules better;

8. Time and travel expended in relaying or delivering messages has been cut.

CUTS TRAVEL TIME

Two-way radio has found a place in other types of strip mining, too. The Fidelity Mine in Du Quoin, Illinois, tried telephones and then power line carrier before deciding that wire lines simply couldn't do the job. "We were spending too much time driving from one pit to another, back to the office, back to the pits and over our 14 miles of haulage," explains the superintendent.

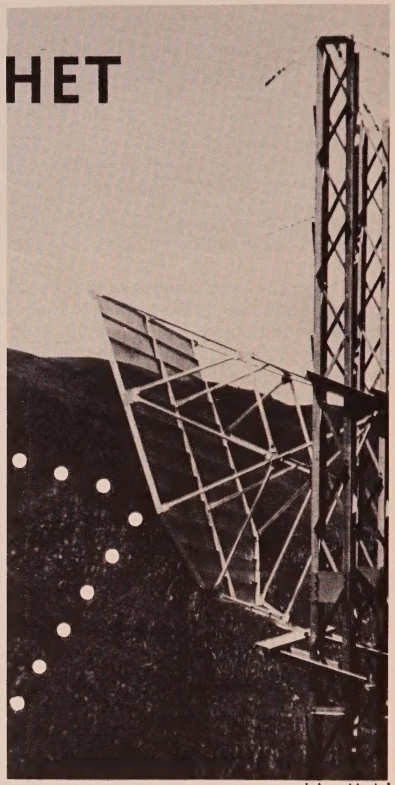
Within a few weeks after the Motorola system of remotely controlled base station and 15 mobiles was installed in 1949, the management found the radio was helping in almost every phase of operation, from blasting to road building. The hours of waiting for a supervisor to be located in event of breakdown are cut to seconds. Trucks are kept working throughout the day, shuttling from one loader to another as supply conditions change.

Even in the coal preparation plant, radio pays off. With equipment geared to a 1,000-ton-per-hour output, the feed has to be constant, otherwise too high a percentage of coal is washed away. To counteract this, as soon as the shovel operator sees that output is down he radios the plant foreman and the controls are changed to a lower ton-hour output ratio.

Radio operation ties the whole mine area together, cuts time lost tracing supervisors, enables the dispatcher to keep constant track of trucks and other mobile units, and increases safety protection of employees.

To an outsider, the natural first question is: "How do you operate a mine with radio?" The miners answer with a question of their own: "How did we ever get along without it?"

HIGH SIERRA RICOCHET



This outsize bank shot is made over and over again as messages speed back and forth between the Kern River No. 1 hydro-electric plant and the Magunden Substation operated by the Southern California Edison Company in the Sierra Mountains. Despite the proportions represented on the page, the upper leg is 12 miles long and the lower leg only 1800 feet long. The Kern River terminal station antenna (lower, left) is tilted upward at a 30° angle to beam the signal over the craggy peaks that separate the two stations.

LENGTHENING THE ARM OF THE LAW

Sheriff R. L. Seaver (above) of Greene County, Tennessee reaches out over 50 miles via two-way radio to his department's two radio-equipped cars. The system, which operates on the same frequency as the Greenville police, also includes "Handie-Talkie" units (left) operating on the highway patrol frequency. This type of system and the portable facility provides close cooperation between all three agencies —sheriff, police and highway patrol.

PROGRESSIVE PARK RANGERS

Park rangers in Salamanca, New York are prepared to cope with any emergency through a two-way radio network tied into county-wide fire and police radio systems. Ranger Marshall Eckenrode (below) and Ranger Charles Lapp (right) demonstrate the new system.

BURGLAR'S

ABOVE: Guards get their orders even when out of the trucks. A loudspeaker outside the cab shouts radioed messages.

Fire and felons are the best friends of a hard-working Denver businesswoman, Mrs. Sara Jackson, because they're her worst enemies. She heads a $250,000 burglar and fire alarm system which has found two-way Motorola radio indispensible in protecting more than 1,400 businesses and homes.

Her electric "watchdogs" are hidden on hundreds of doors and windows, and a broken contact on any one flashes a signal immediately to the heavily-guarded headquarters of Denver Burglar Alarm Company. Armed guards are sent speeding to the scene, and they maintain constant contact with headquarters via radio.

The protective service reached its heyday during World War II when the manpower shortage spurred installations of electrical alarm systems.

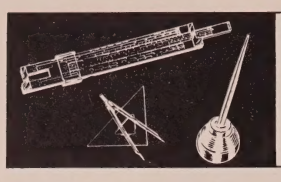
First year of operation has shown Mrs. Jackson's 460 mc. radio system to be very effective in blanketing the downtown area of Denver with its tall buildings. Radio is helping Mrs. Jackson and her guards keep their reputation as the hoodlum's private enemy No. 1.

BELOW: Row upon row of meters flash trouble to Mrs. Jackson in the control center. Guards rushed to the scene keep her informed of what they find amiss.

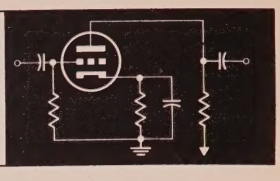
BUGABOO

ABOVE: Crooks don't like Denver Burglar Alarm Co. Four times in two years the central station has been rocked by explosions. Now the office and Mrs. Jackson's near-by home are virtually "bomb-proof."

Mrs. Jackson's personal auto and three trucks are equipped with Motorola two-way radio for instant contact with the office.

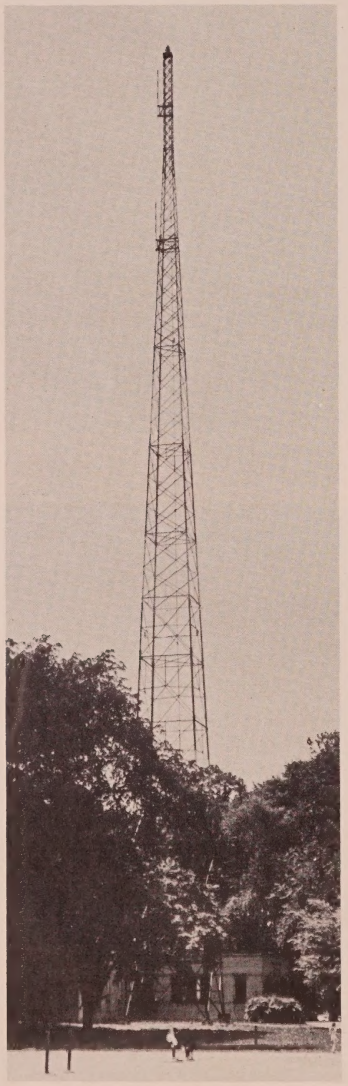


Technical Notes Section



DRYING COAXIAL LINES

by Lloyd P. Morris, Chief Engineer
Motorola National Radio Systems Consulting Service



For the most efficient operation of base station antenna systems using coaxial feed lines, it is extremely important that such lines be kept completely free from all moisture. One of the simplest and most effective methods of drying coaxial feed lines, where automatic dehydrating equipment is not available, is to flush the cable from one end to the other with low pressure dry nitrogen. This flushing process can ordinarily be completed in one day. However, when time permits and especially where excessive moisture is present, two full days may be required.

RESISTANCE MEASUREMENT

Ordinarily, the presence of moisture in coaxial feed lines is easily detected by making a DC resistance measurement from the center, beaded conductor to ground. In a completely dry line, the measured resistance should be in the order of megohms. When making this measurement, the antenna, phasing networks and other external equipment should be disconnected from the line to eliminate any error in resistance measurements.

The easiest method is to flush the line from the bottom to the top. In many installations a stop or petcock is provided at the top end of the line which may be opened to allow the dry nitrogen gas to flow through. In other installations it is necessary to cut the line at the top with a pipe cutter or hack saw. To prevent contamination by saw filings falling into the line, it is important to bend the upper end of the coaxial line so that it is pointing downward. After sawing, tap the cable lightly and bend slightly in all directions so that all foreign metallic particles fall out. At this stage it is also well to file or chamfer any rough edges of the inner and outer conductors to simplify re-assembly.

In bending the line at either end, be extremely careful not to make the bend too sharply. To make a large bend, it may be necessary to loosen the cable's supporting fixtures far down from the point at which the cable is to be cut. The work should be planned to minimize bending the cable back and forth. Some of the air dielectric coaxial lines "work harden" very quickly to the extent that excessive bending may fracture the outside conductor. This makes it necessary to do all the cleaning and make-ready operations at the same time.

DRY NITROGEN

Probably the most convenient dehydrating agent for this application is "oil pumped" dry nitrogen. "Water pumped" dry nitrogen should never be used. Dry nitrogen cylinder pressures are greater than 2,000 pounds per square inch and it is therefore

necessary to use a regulator to reduce the pressure to approximately one pound per square inch at the inlet of a reasonably long length of coaxial line. A one pound per square inch pressure at the inlet of a one to three hundred foot span of line will flush at a rate of one to two hundred cubic feet of equivalent free gas in one day. The cost of 200 cubic feet of free dry nitrogen gas will ordinarily be between $4.00 and $8.00.

It may be necessary to borrow or rent a low pressure gauge to determine inlet gas pressure since standard coaxial line gauges are not ordinarily sufficiently sensitive.

WATER IN LINE

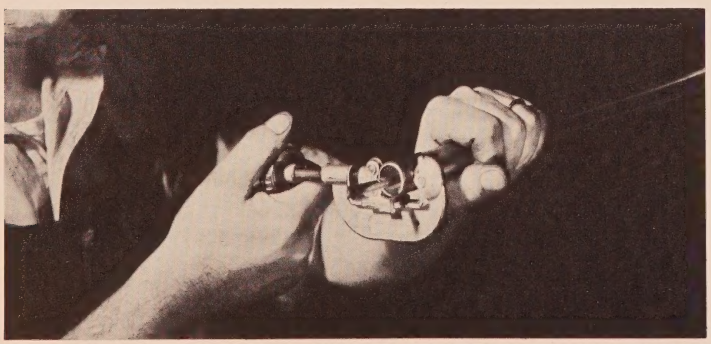
If, in a horizontally installed line, there are low spots or dips which may contain water, additional precautions must be taken. The line should be drained first by drilling a small hole at the bottom of the lowest spot. It will take a considerable amount of time for the line to drain if the water extends beyond several insulator beads. After the water has completely drained, a blow torch may be used to heat the line to remove the remainder of the moisture by evaporation. Heat will not affect most insulations, but to be safe it is best to check the characteristics of the line used. "Teflon" beaded cable will withstand temperatures well above the boiling point of water when the heat is applied for short periods of time. Ceramic beads will withstand higher temperatures; however, heat must be applied evenly over all the area to prevent the development of unequal stresses in the ceramic insulators. If only a small amount of water is believed to be in the line, it may be unnecessary to drill a hole. The application of heat may be sufficient. If a hole has been drilled in the line, the hole should be carefully soldered before the final drying operation is completed.

Any DC resistance measurements from the center conductor to ground should not be made until the line has been allowed to cool. This will give any moisture collection a chance to show up as condensation on the surface of the insulators.

SPLICING

To re-assemble a line that has been cut, a universal bolt-on type of flange may be used if there is a possibility that flushing may again be necessary at some later date. Or, it may be desirable to install a plumbing type of nut and gasket coupling where sealing is accomplished with a rubber "O" ring type of seal. It is obvious that in making this type of junction, it will be necessary to carefully match the impedance of the line involved.

The simplest and least expensive method of splicing a line that has been cut is to join the ends with a sleeve (Motorola Splice Kit K-9258) for the outer conductor and a soldered center conductor. When soldering the center conductor, care should again be taken to prevent solder from getting inside the cable. A rag stuffed inside the end of the line will usually serve the purpose.



Cut inner conductors ¾" longer than outer conductors. When cutting the line, be careful not to crimp the outer conductor or re-assembly will be more difficult.

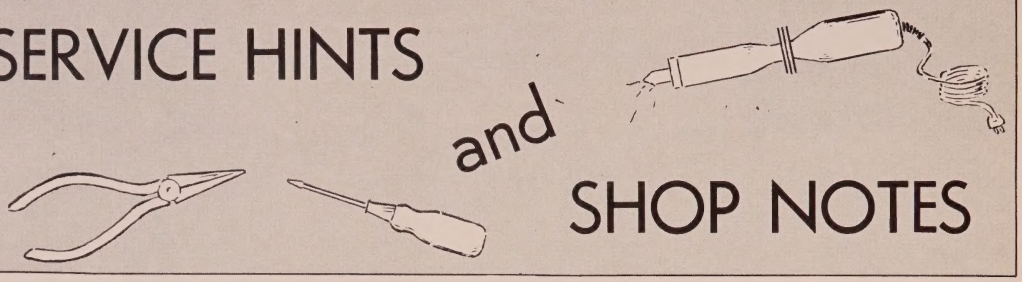
Before starting the flushing operation, carefully outline the steps to be taken and equipment required to minimize repeat trips to the tower top.

After the line has been flushed and again pressurized, the soap, water and bubble method may be used to detect leaks. The most sensitive method is to fill the line with a refrigerant gas at higher pressures and use a refrigerator color flame torch detector. Although more sensitive, the latter method is more costly than the soap, water and bubble method.

Drying coaxial lines is admittedly a more comprehensive subject than space has permitted in this article; however additional detailed information is available upon request.

The author wishes to acknowledge the contributions made by members of Motorola's field organization and others outside of the organization who have made helpful suggestions.

SERVICE HINTS and SHOP NOTES



POWER SUPPLY

Brad Trask of Smeed Sound Service, MSS in Eugene, Oregon, developed a test bench power supply for use in servicing mobile equipment. The basis of the system is a 6 volt battery. Two AC to DC converters (ATR "A" eliminators in this case) are used in parallel and are, in turn, in parallel with the battery. An automobile generator cut-out (low voltage cut-out) relay is used to disconnect the converters from the line when they are turned off. A heavy duty double pole-double throw switch permits reversal of the output voltage to accommodate both negative and positive battery ground. As shown in the diagram, the circuit can be easily constructed in the shop.

FRONT MOUNT

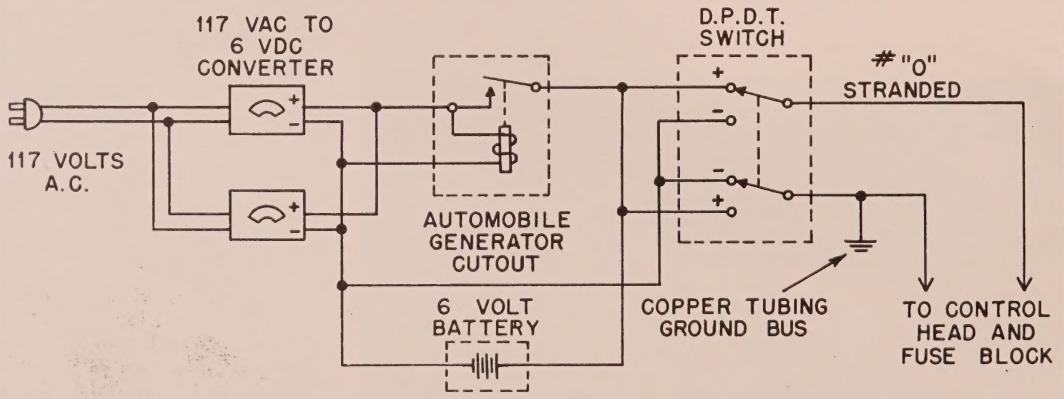
John Drake, MSS in Toledo, Ohio, devised his own solution to the problem of how to mount a Motorola under-dash mount radio unit in the 1954 Plymouth. The standard mounting brackets supplied did not provide a simple solution, so to mount the radio over the "hump" in the front seat, two strap iron brackets were devised to place the unit in its proper position. As shown in the illustrations, the radio unit is readily mounted where it is easily accessible to the driver. The specific installation is the Red Cab Company of Toledo.

ORDERING

When ordering new or replacement crystals for two frequency receivers which include two crystals in a single crystal oven assembly, be sure to specify which crystals are desired. For optimum operation, the crystal must be matched to its own oscillator circuit and it thus becomes necessary to specify whether the crystal is for frequency number 1 or frequency number 2. This applies to all Type F01 through F07 crystals used in Type E01 through E07 crystal and oven assemblies.

IGNITION CABLE

When you run into one of those stubborn ignition interference problems for which it appears there is no further solution, try checking the continuity of the spark plug leads. Through use of an ohmmeter or other continuity indicator (such as a dry battery



A 6 volt bench power source as used by Smeed Sound Service in Eugene, Oregon.

and small bulb) you may find that the lead between the distributor and the spark plug is open.

The first place to check is the spark plug end of the lead. In an ignition system where the end of the lead and the terminal are molded in rubber, the terminal is probably **not** soldered to the conductor. The electrical connection may be strictly mechanical.

Use a pair of pliers and squeeze the rubber housing just below the bend in the terminal. If the indicator registers continuity, the lead is probably satisfactory. With an intermittent indication, the connection is unsatisfactory. The quickest remedy is to open up the rubber housing and actually provide electrical continuity by soldering the conductor to the terminal. Suitable protection against weather induced terminal corrosion should be provided in the opened terminal.

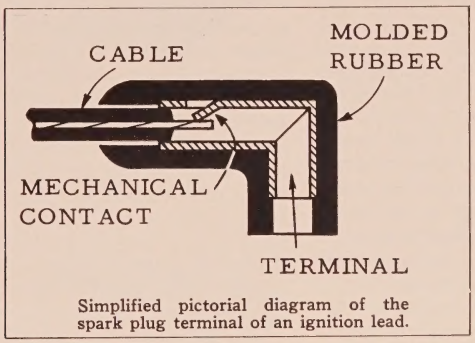
Although a defective lead can be replaced with a new lead, even the new lead should be checked. It also may be open-circuited. If necessary, check each new lead when it is purchased. Open leads may appear satisfactory from an ignition standpoint.

In addition to aiding in reducing ignition interference, lead continuity will probably also provide smoother engine idling.

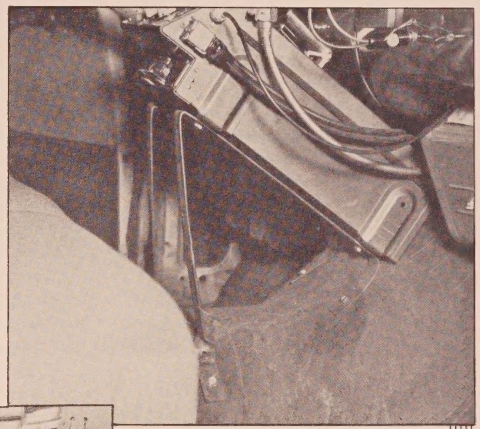
PAINT

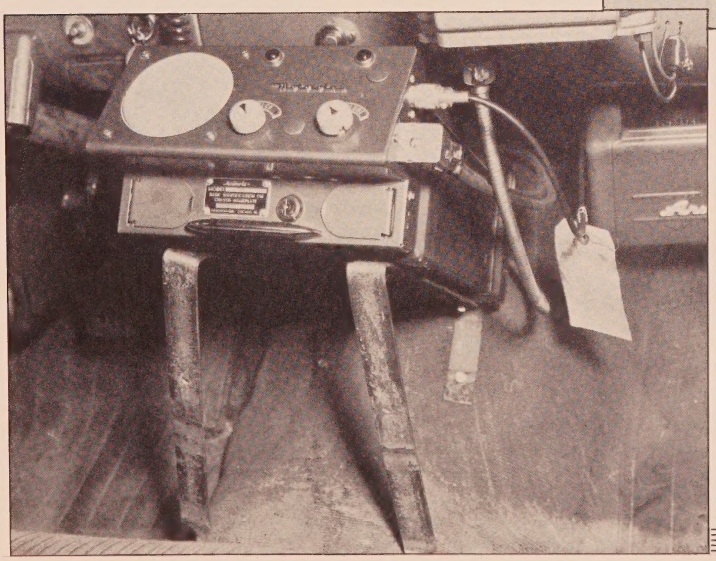
E. H. Abel of Moto-Radio in San Diego, California offers a suggestion which practically eliminates drop light usage in drive-in service shops.

A white rubber-base paint is applied to the concrete garage floor. The white surface reflects light from the overhead fixtures aiding in the illumination of the underside of the vehicles with reflected light. Of course, it also brightens the entire shop area with the reflected light.

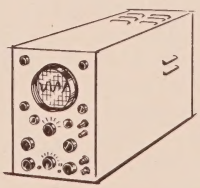


Simplified pictorial diagram of the spark plug terminal of an ignition lead.





Home made mounting brackets support a front-mount Uni-Channel radio unit as designed by MSS Operator John Drake.



THE **Motorola** PHASE MODULATOR

a description of the low-distortion modulator circuit used in Motorola 2-way radio transmitters.

The stability of an independent crystal controlled oscillator and the simplicity of the modulator circuitry have resulted in phase modulators supplanting frequency modulators in both broadcast and communications FM radio systems. The audio modulation characteristics of a PM transmitter are identical to those of an FM transmitter with pre-emphasis, hence both are generally called FM transmitters. This article describes briefly the modulator circuit of Motorola 2-way radio transmitters.

CIRCUIT

The essentials of the modulator are shown in the simplified schematic diagram. While capacitors C1 and C2 are shown for this version, it is possible and practical to substitute appropriate inductors without any change in operation or performance.

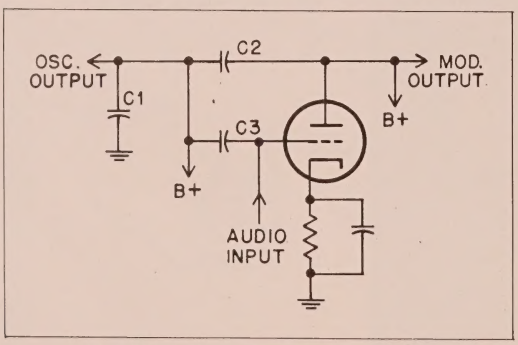
The simplified diagram can be reduced to an equivalent electrical circuit by reducing shunt capacitor C1 plus stray capacitance to an equivalent series impedance, Z1, since the oscillator is essentially a very high impedance RF generator. Capacitor C2 becomes impedance Z2. The tube can be considered as a generator in series with a resistance but by coupling RF energy to its grid from the junction of Z1 and Z2 (through C3) the generator can be replaced with an equivalent impedance, Z3, and a resistance R when the tube characteristics are known. The audio voltage fed to the grid has the effect of varying R which causes a phase variation of the RF signal.

A comprehensive analysis of the circuit will disclose that when Z1 and Z2 are equal and of the same sign and Z3 is of the same magnitude but opposite in sign to Z1 and Z2, the following characteristics are found in the modulator under conditions of constant input voltage: 1. the output voltage is constant regardless of the variations in the resistance, R. 2. the phase shift between input and output voltage is proportional to the variation of the resistance, R. Hence, by varying R (by varying the audio input voltage), the phase relationship of the input RF signal to the output RF signal is varied in accordance with the modulating voltage.

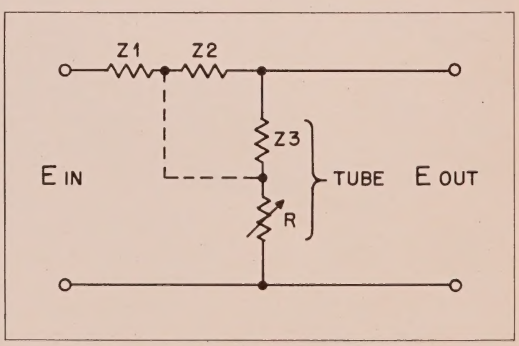
OPERATION

From a simple inspection of the equivalent circuit, it is obvious that a phase shift of RF voltage will occur because of the resistance-reactance relationships of currents and voltages. The tube (and its operating point) and impedances Z1 and Z2 must be chosen to fulfill the requirements listed in the previous paragraph. As R is varied from zero to infinity, the amount of phase shift is varied from zero to 180°. This phase shift (±90°) is twice that obtainable from earlier modulators and thus requires only one-half the multiplication of the RF signal to reach the necessary deviation at the carrier frequency. By using only a small amount of the total available phase shift (less than 40% in actual practice) the distortion in the modulator circuit is maintained at a very low level. By mathematical analysis it can also be shown that since the RF output voltage is constant for a constant RF input voltage, there is no amplitude modulation of the carrier.

This phase modulator is one more reason for unexcelled performance in Motorola 2-way radio systems.



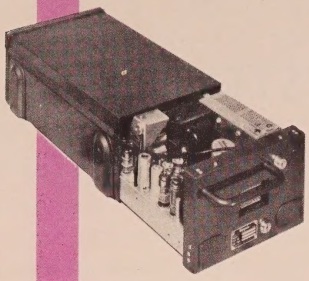
Simplified Phase Modulator Schematic Diagram



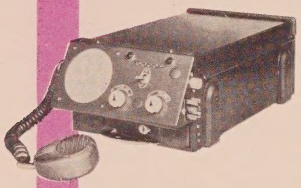
Phase Modulator Equivalent Circuit

NEW PRODUCTS

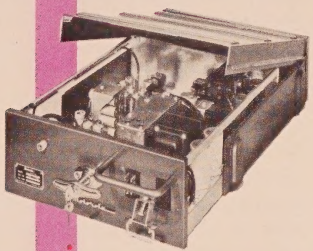
The UNIVERSAL UNI-CHANNEL 6/12 volt Mobile Radio Units



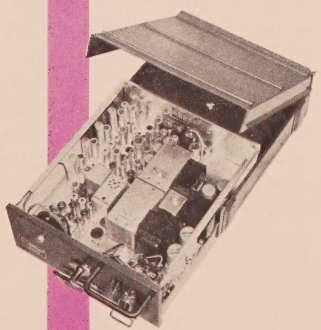
T41G, T33G AND T43G MOBILE UNITS



D41G, D33G AND D43G MOBILE UNITS



T51G MOBILE UNIT



T44A MOBILE UNIT

With the addition of new models throughout the past year, virtually any type of two-way radio unit required is now available in the UNIVERSAL UNI-CHANNEL 6/12 volt series.

25-54 MC.

As previously announced, a family of models in the T41G series covers the 25-54 mc. range. These models have an RF power output of 25-30 watts and are mounted in the familiar Motorola 10 inch (wide) mobile housing. The smaller physical size for this power output is made possible by the increase in power supply efficiency which minimizes primary power input and temperature rise within the housing. The T41G series is designed for installation in an automobile trunk with a dash mounted control head and speaker. A companion series with built-in control head and speaker for under-dash mounting is the D41G series. For operation from 117 VAC, the same transmitter and receiver are employed in the L41G AC Utility series models.

A big brother to the T41G series is the T51G series with 50-60 watts RF power output. While the same basic transmitter chassis and receiver chassis are used, a higher voltage power supply produces greater transmitter output. The T51G series are included in the conventional Motorola 15 inch mobile trunk mount housing.

144-174 MC.

The T43G series (trunk mount) and D43G series (under-dash mount) mobile units and the companion L43G (AC Utility) are 20-25 watt units mounted in the 10 inch mobile housings.

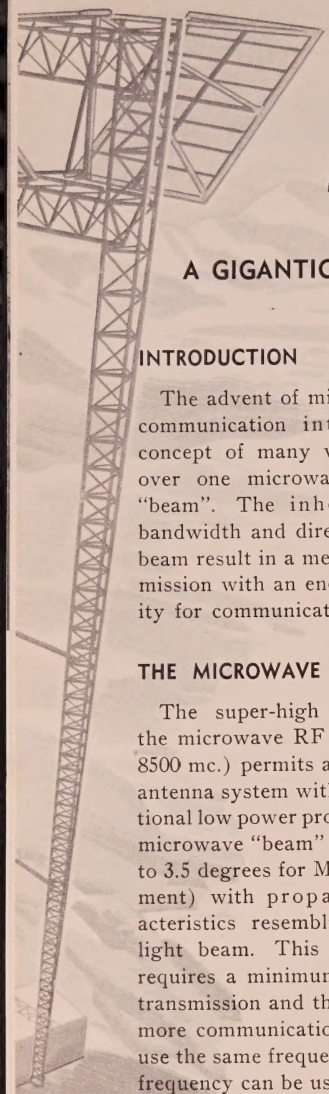
Late additions are the T33G and D33G series 10 watt mobile units which are identical in outward appearance to the T43G and D43G series. The transmitter and receiver chassis are identical to those in the 25 watt series, the difference once again is in the power supply output voltage for the transmitter.

450-470 MC.

Since shortly after their inception several years ago, the Motorola 18-20 watt mobile units in 15 inch housings included the 6/12 volt feature. These models, the T44A series utilize the deluxe Sensicon receiver chassis and are all designed for trunk mounting with a dash-mounted control head and speaker.

TRUE 6/12

Early in the development of the 6/12 volt feature, the Motorola Engineering Department realized the requirement for fool-proof interchangeability. Any modification in the radio unit which would be required for a technician to transfer a unit from a 6 volt vehicle to a 12 volt vehicle poses a hazard. Equipment damage could result if the modifications, jumper changes or adapter applications were incorrectly made. Hence, Motorola developed the true 6/12 volt equipment wherein all units are identical and it is impossible to make an error in transferring the radio drawer unit from one vehicle to another regardless of electrical system voltage. The power cable wiring arrangement automatically makes the proper connections.



MICROWAVE RELAY SYSTEMS

A GIGANTIC YET ECONOMICALLY FLEXIBLE CAPACITY FOR COMMUNICATION

INTRODUCTION

The advent of microwave relay communication introduces the concept of many voice channels over one microwave carrier or "beam". The inherently wide bandwidth and directivity of this beam result in a medium of transmission with an enormous capacity for communication.

THE MICROWAVE BEAM

The super-high frequency of the microwave RF carrier (5925-8500 mc.) permits a very efficient antenna system with highly directional low power propagation. The microwave "beam" is narrow (1.2 to 3.5 degrees for Motorola equipment) with propagation characteristics resembling a searchlight beam. This narrow beam requires a minimum of space for transmission and therefore allows more communications systems to use the same frequency. The same frequency can be used to transmit information from one location in different directions or it may be repeated several times in different locations of any particular relay system. Narrow beam transmission causes less disturbance to other systems, and, conversely, is less sensitive to disturbances by other systems.

FREQUENCY-DIVISION MULTIPLEXING

Frequency division multiplexing is widely used in point-to-point communications to provide several independent voice channels on a single RF carrier. The multiplexing system designed by Motorola utilizes 25 FM subcarrier frequencies (400 to 800 kc.) to provide 24 voice channels and one service channel over the microwave beam. More voice channels are possible with different multiplexing methods, but the equipment is proportionately more complex and expensive. The FM subcarrier method of multiplexing provides a superior signal-to-noise and crosstalk ratio, and experience has shown 24 voice channels to be more than required by most privately owned systems.

FLEXIBILITY

Electrical

Subcarrier voice channels can be added with negligible degradation of the signal-to-noise ratio per channel. Neither the microwave bandwidth occupied nor the possibility of interference to microwave receivers on adjacent frequencies is affected by the number of subcarrier channels. Subcarrier channels can be dropped or inserted as desired in the system and they can be used for many different applications between different relay stations. System adjustment procedure and test equipment is essentially the same for any number of subcarrier channels (from one to twenty-four in Motorola equipment).

Mechanical

Additional subcarrier equipment can be easily added to existing cabinets. Power supplies and RF equipment are not changed. Subcarrier transmitters and receivers can "plug-in" to existing subcarrier frames and cable installations in most cases.

Economical

The majority of the cost of a microwave system is in the initial installation of towers, reflectors, shelters, stand-by power equipment and RF equipment. When the RF and antenna system is in place, the only additional costs involved in expanding the system to a greater number of voice channels is that of the "add-to" multiplex equipment which is added to the original multiplex equipment. For example: on a motorola system consisting of two typical stations, 22 additional channels can be incorporated into an existing two-channel system for approximately the original investment cost of the two-channel system (12 times the communication for twice the price). Since, on longer systems with many relay stations, multiplex equipment will probably be used at every third or fourth relay station, the same 22 additional channels can be incorporated for a very small percentage of the original investment cost.

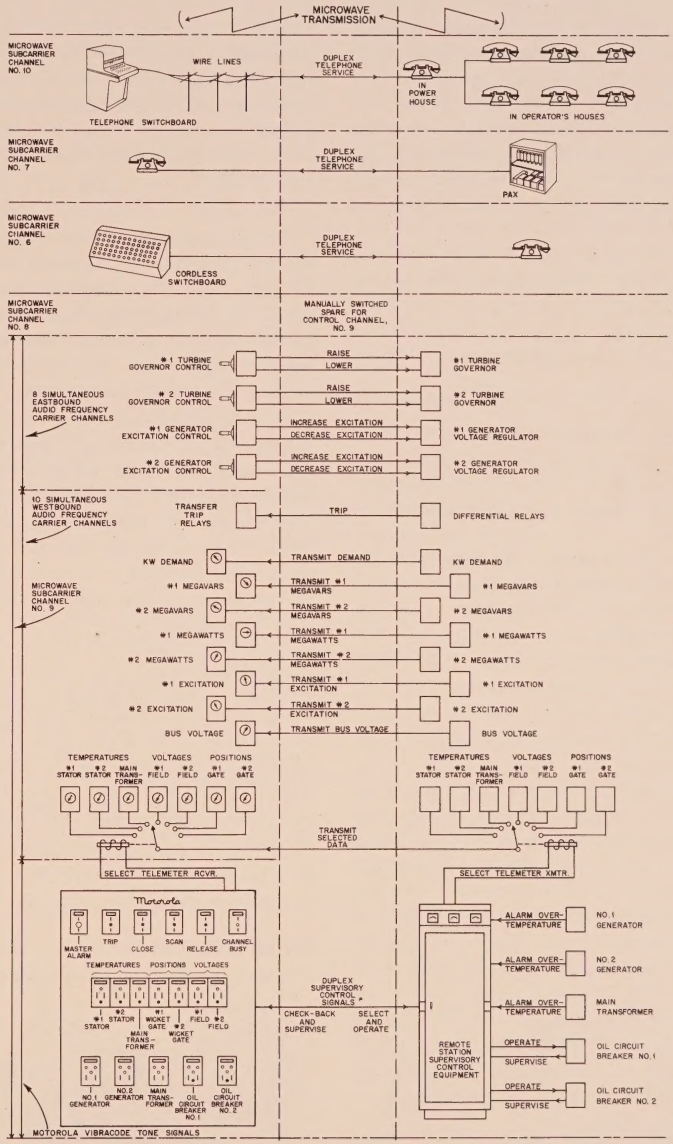
TERMINATING EQUIPMENT

In the Motorola multiplexing system, each FM transmitter and receiver (and therefore each voice channel) is terminated by a "voice

terminal" which contains the audio termination circuits and such DC relay functions as necessary for a specific type of circuit. Since the type of circuit over each voice channel is determined by the voice terminal, maximum utilization of voice channels into a flexible assignment of circuit types is possible. Motorola currently has over 12 different types of voice terminals which provide every conventional type of telephone circuit (as well as remote VHF base station operation) over the microwave system. Some of these basic telephone circuits are listed below.

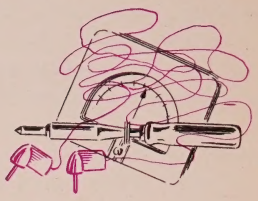
1. Simplex party line (magneto ring)
2. Duplex party line (push-to-ring)
3. Simplex private line (magneto or push-to-ring)
4. Duplex private line (magneto or push-to-ring)
5. Various dial telephone circuits including intertoll dial and trunk tie-in

A voice terminal is also available which provides an audio circuit with no DC relay functions over one voice channel of the microwave system. This voice terminal is used to terminate Motorola supervisory control and AF (audio frequency) carrier equipment. The standard Motorola supervisory control system transmits up to 90 control and supervision functions over a portion of one voice channel. If necessary, however, additional control and supervision functions can be added over the same voice channel to accommodate **any** system. Each AF carrier channel can carry one teletype or telemetering circuit. Up to 90 supervisory control functions and 18 AF carrier channels can be carried simultaneously over the same voice channel; or, up to 90 supervisory control functions, a telephone circuit, and up to 5 AF carrier channels can be carried simultaneously over one voice channel. The immense capacity of a full 24 voice channels for communication and control circuits is readily apparent. Wideband AF carrier equipment (four channels per voice channel) is also available where special control functions require greater speed of transmission.



Channel utilization in typical microwave system for electric power company shows functions possible with only five (5) voice channels. The immense capacity of twenty-four (24) voice channels for communication and control circuits is readily apparent.

ON LOCATING INTERMITTENTS



A condensation of a technical paper by Frank A. Bramley, Regional Service Manager, (New England States) Motorola Communications and Electronics, Inc.

Locating the cause of intermittents in electronic equipment is an ever-occurring problem. Unnecessary delays result in the dissatisfaction of the user through lost service and present difficulties in charging time and collecting fees for the actual time spent.

Some possible causes of intermittent operation may be caused by the extremes of:

1. Heat and Cold
2. Vibration and Shock
3. Voltage and Current
4. Humidity and Dust
5. Time and Temperament

To these may be added the peculiar idiosyncracies of individual operators, the vagaries of the atmosphere or transmission medium, and what may be described as the chance concurrence of fortuitous factors, sometimes referred to as pure cussedness.

Nearly all intermittent conditions may be traced to circuitry failures such as shorts and open or loose connections. The problem is to find them—to have the condition occur in the presence of the repairman. Too frequently the repairman is out when the trouble is "in," or vice versa. The problem thus becomes one of inducing the trouble to occur often enough and to remain "in" long enough for its cause to be determined.

HEAT AND COLD

Since extremes of temperature are a common cause, it is obvious that **both** extremes should be investigated. Servicemen have used heat to produce failures for some years, but it remained for one taxi owner to put the whole set in a beer cooler and locate the trouble **immediately.**

Equipment may be quickly subjected to abnormal heat on the bench by use of an infra-red heat lamp. It is suggested that every well-equipped mobile service bench might well be equipped with a gooseneck lamp normally furnished with a 100 watt bulb for inspection of hard-to-see places. This item will, itself, aid in locating intermittents, and then, if the heat lamp is substituted, the whole or parts of the chassis may be quickly brought to a very high temperature. If the lamp is within 3 to 5 inches of the chassis, it seldom takes more than 5 minutes to bring the equipment well above any reasonable operating temperature. A sheet of alumnium with one-inch hole, if used as a screen, will aid in localizing the heat. Excessive heat may cause failure of some components so that it is possible that additional problems can be created by this method if used indiscriminately.

DOUBLE FEATURE

The most confusing feature of trouble shooting is the "double feature"—the double-troubles with similar symptoms but separate causes. Don't overlook the unfortunate fact that equipment often contains two, or even three, simultaneous troubles having similar symptoms. Many failures to find intermittents can be laid at the door of the double feature. After all, almost anything might cause a set to go dead. Don't overlook both heat and cold and both the mechanical and electrical effects of each.

VIBRATION

A second important cause of intermittents is loose connections induced by vibration and shock. These conditions may be difficult to reproduce without a variable frequency shake table but usually such expedients are unnecessary. Poor grounds are most common. Coil shields and equipment frames, especially, should be checked. Try prying each can in various directions with a screwdriver. Riveted or swaged contacts are often at fault. Solder them over, if possible, or make bolted connections, using lock washers or pigtail connections when necessary. Provide solid conductors to replace intermittent common circuits between chassis.

Changes in value of capacitors,

HEAT AND COLD

SHOCK AND VIBRATION

inductors and resistors are possible due to each of the four fault-focusing factors: temperature, vibration, voltage and humidity.

VOLTAGE

Improper voltage and current may often cause intermittent conditions. Low voltage tends to prevent oscillations or make oscillator circuits unstable. Some means of gradually changing the voltage of primary supplies should be available on any well-equipped test bench. Vibrator and relay operating limits may be checked in this manner. In order to thoroughly check tube and circuit conditions, the voltage should be changed **very slowly** to allow tube temperatures to follow voltage changes.

Circuit failures may sometimes occur only at higher than average voltages. Always increase the voltage **slowly.** Tubes are vulnerable to over-voltage and both tubes and vibrators have reduced life if voltages are as much as 10% above normal. Tube shorts may occur only at excessive temperatures. Grid currents may become excessive if filament and heater voltages are high. The result can be abnormal plate currents and rapid tube failure. Such faults can occur in any tube especially if operated at a high temperature for a long period.

RELAYS

Relay faults constitute some of the most difficult of intermittents. Metal filings, dust and oxidation are common causes. Metal filings, resulting from careless repairs or abrasion and vibration, manage to get between the pole piece and the armature and cause partial or complete lack of operation. Peculiarly, these filings only interfere occasionally yet remain in a position to cause intermittent trouble for long periods. Dust is a mortal enemy of small relays. The light contacts involved are easily held apart by small dust particles. Contamination of the contacts by oxidation, dust, and grease films of atomic thickness will prevent the flow of small currents. Contacts must be cleaned with **very mild** abrasives. Point files are much too coarse. The relay frame must be **tight**; operation **firm** and certain. Contacts must **travel** far enough to **wipe** their opposite members and be capable of **overtravel.** If cleaning with solvents such as carbon tetrachloride is attempted, the equipment must be allowed to dry thoroughly, then the contacts must be recleaned by the mechanical method, or else a film of the grease may be left on the contacts with conditions worse than before. Always wash twice, wipe once.

Dust and dirt accumulations anywhere in electronic equipment can lead to trouble, especially when combined with moisture and high voltage. Dust plus moisture causes increased losses and may prevent desired oscillation, decrease gain or increase distortion. These conditions may well be intermittent due to variations in temperature and humidity.

FACTORS

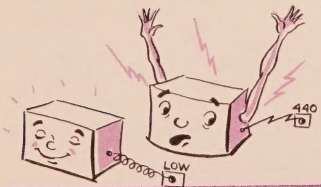
If none of the foregoing electrical and physical conditions will cause the intermittent trouble to appear, the cause may easily be laid to the innate cussedness in inanimate objects and sometimes only patient waiting and good fortune will give the technician a "break". Often several definite troubles will be located and as definitely removed before the basic trouble is discovered — often through good fortune rather than good management.

The fact that a trouble may occur at a particular time of day, day of the week, with only a particular operator, etc., should not be overlooked. Possibly this fact may be a clue. A particular voltage condition may then be present, a particular person may be using the equipment or other special conditions may be present. Determine what they may be.

WARNING

The location of faulty parts by these methods does not guarantee success in locating an intermittent condition. Failure to locate the real cause if often due to the smokescreen of finding other troubles, definite though they may be. Always review the original complaint. Ask yourself, could this have been the real trouble? If the answer is "yes", don't be too sure. Most failures to find the real trouble are due to a rationalization and perversion of the symptoms to conform with what you did find, not the real trouble that you did not find. Be honest with yourself.

The complete text of this paper is available from the Technical Information Center upon request.



VOLTAGE AND CURRENT

DUST AND HUMIDITY

TIME AND TEMPERAMENT

TRANSMISSIONS ..... On Communications Topics

Dig That Crazy Cavity

Occasionally, the police move faster than their communications system. Recently, the Alameda County Sheriff's office in California ordered a radio car to investigate a complaint on a hole in the pavement on Cherry Road.

The reply: "This is Car 297. We have already found the hole. Please send a tow car to get us out."

Two-Way Radio With a Woofer?

The English frequency spectrum is apparently bigger than ours, judging by the radio applications they find room for. A man in Grimsby, England, has a two-way radio system rigged up between his house and his kennels. If the dogs bark too much, he picks up the microphone and tells them to be quiet.

A Convincing Pitch

A while back, **"Bill" Whiting,** Director of Communications, Radio Communications Department, Bakersfield, California, appeared before the state board of supervisors to speak on behalf of a proposed radio system. Only moments after he had reminded the assembled group of the telephone tie-up after the 1952 earthquake, the building began to quiver as a minor quake hit the area. No damage was done, but no one knew that at the time. The board adjourned for five minutes to inquire into the extent of the damages. Each supervisor grabbed a phone to check on the area in which he was particularly interested only to find the switchboard absolutely clogged. Meanwhile, Bill Whiting stepped outside to the two-way radio unit in his car. Within a few minutes he was back inside with a full report for each of the supervisors on the extent and effects of the quake throughout the county. He's got a real bag of tricks.

Erehwon

One day last week a big Cadillac convertible pulled up at a stop light next to a big Rolls Royce sedan. The radiophone in the Cadillac rang and the driver answered, thusly: "Hello," a pause, then, "Not at all." He then reached over and handed the receiver to the driver of the Rolls Royce.

"It's for you," he says.

REGIONAL DIRECTORY

For your convenience, there is listed below a complete directory of Regional Managers for Motorola Communications and Electronics, Inc. together with their offices and territories covered.

REGION 1
HENRY C. GAMMELL
Arizona, California, Idaho, Montana, Nevada, Oregon, Washington, Wyoming, Utah.
Office: 811 South "B" Street
San Mateo, California
Phone: DIAMOND 4-6386

REGION 2
EUGENE F. BROWN
Colorado, Iowa, Kansas, Minnesota, Nebraska, North Dakota, South Dakota.
Office: 817 Kilpatrick Bldg.
Omaha, Nebraska
Phone: WEBSTER 0017

REGION 3
HOMER L. MARRS
Illinois, Indiana, Missouri, Wisconsin.
Office: 1327 W. Washington Blvd.
Chicago, Illinois
Phone: TAYLOR 9-2200

REGION 4
GLENN MUNRO
Kentucky, Michigan, Ohio, Tennessee.
Office: 19142 James Couzens Hwy.
Detroit 35, Michigan
Phone: UNIVERSITY 3-6464

REGION 5
EDWARD L. FALLS, JR.
Arkansas, Louisiana, New Mexico, Oklahoma, Texas.
Office: 171 Parkhouse Street
Dallas 7, Texas
Phone: STERLING 4951

REGION 6
HORACE E. BOYLAN
Alabama, Florida, Georgia, Mississippi, South Carolina.
Office: Stallings Bldg., Rm. 601
1829 First Ave., North
Birmingham, Alabama
Phone: 4-4582

REGION 7
JOHN F. FUSSELL
Delaware, Maryland, North Carolina, Virginia, Washington, D.C., West Virginia.
Office: 2309 Calvert St., N.W.
Washington 8, D. C.
Phone: ADAMS 4-5620

REGION 8
P. R. KENDALL
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont.
Office: 540 Main Street
Winchester, Mass.
Phone: 6-2482

REGION 9
LOWELL E. WHITE
New Jersey, New York, Pennsylvania.
Office: 102 Linwood Plaza
Fort Lee, New Jersey
Phone: 8-9100

REGION 11
FRANK W. WALKER
Arizona, Southern California, Southern Nevada.
Office: 6555 Sunset Blvd.
Hollywood 28, California
Phone: HOLLYWOOD 2-1378

WASHINGTON D. C. OFFICE
L. HARRISS ROBINSON
Federal Agencies

NATIONAL RAILROAD SALES
R. FLOYD McCALL
Office: 4501 Augusta Blvd.
Chicago 51, Illinois
Phone: SPAULDING 2-6500

New Carrier Line Shown

Motorola's new wideband audio frequency carrier line was introduced April 26-28 in College Station, Texas, when Leonard G. Walker, power utility product engineer, presented a paper at the seventh annual Conference for Protective Relay Engineers.

Walker accepted an invitation to speak on "Protective Relaying Via Microwave" at the informal session at Texas A&M College. The meeting convened for a discussion of joint problems affecting the protection of electrical apparatus and transmission lines.

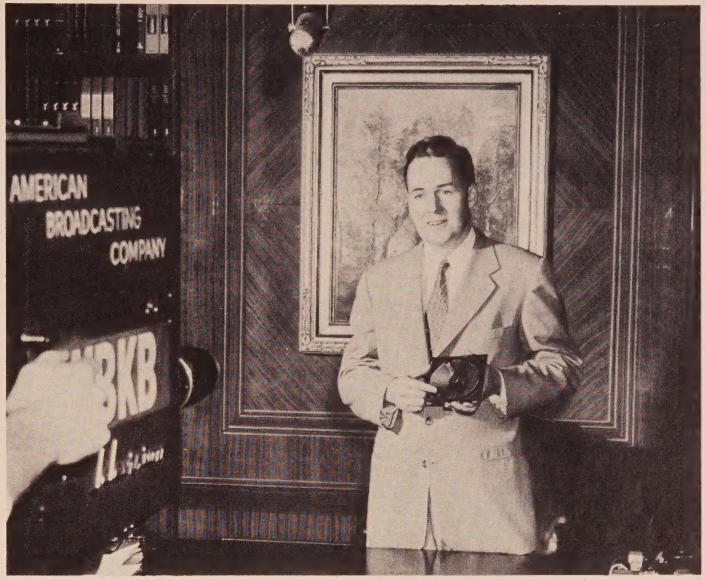
He explained the capabilities and applications of the new AF carrier equipment designed specifically to provide a transmission path for relay "trip" signals.

Walker pointed out that protective relaying via microwave is preferable to wire lines because the same factors of icing, high winds, tornadoes and lightning which put high voltage transmission lines out of service will also affect the relaying wire lines.

ALREADY IN USE

Specialists in the protective relay field from all parts of the nation attended the conference. Walker was co-author of a paper presented at the 1953 session, dealing with the general application of highly reliable channels such as microwave to protective relaying.

The new audio frequency carrier equipment is currently installed for field testing and actual protection of transmission line circuits on the power systems of the Cleveland Electric Illuminating Company and the Bonneville Power Administration.



TV Series Wins Plaudits

Motorola's current television programs are drawing wide press acclaim on two fronts—artistic and commercial. The hour-long live dramatic shows are seen alternate Tuesdays at 8:30 P.M., C.S.T., on the ABC-TV network.

Here are typical reviews of the Theater Guild productions.

ASKS FOR REPEAT

John Crosby, New York Herald-Tribune critic: "The Motorola 'Thirteen Clocks' was entirely enchanting in just about every way a show can be . . . This production is much too good to be lost in a single showing, and I devoutly hope they'll do the whole thing over again some day."

TV Guide: " . . . a worthy addition to the hour-long drama ranks."

Jack Gould, New York Times: " 'The Thirteen Clocks' was a complete and joyous delight, a romp in nonsense that was staged with both spirit and appreciation by the Motorola TV Hour."

Janet Kern, Chicago American: " . . . I've intended to record for posterity my belief that (Motorola's Thirteen Clocks) was one of TV's rarer and more beautiful 60 moments."

On the commercial side, Vice President Robert Galvin's calm talks during intermissions are cited as setting a new high in adult institutional selling. Writes Anton Remenih in Chicago Tribune: "If Bob Galvin didn't already have a good job, he could set the TV announcing trade on fire . . . He and Ken Nordine, commercial announcer, never rabble-rouse or resort to the huckster tactics of a pitchman. They simply treat televiewers as intelligent human beings."

ELECTRONICS SIMPLIFIED

The Cincinnati Times Star says of Galvin: "Excellent native stage presence and poise."

Galvin discusses such electronic topics as trends in radio communications, color television, transistors, subminiature tubes and printed circuits.

Bad Weather? Rough Terrain?

You Can Rely on Motorola® Microwave for NON-STOP PERFORMANCE

Motorola Systems Are In and Working—24 Hours a Day—For Power Companies Across the Nation.

Utilities and power companies everywhere have turned to Motorola Microwave for communications that shrug off bad weather and rough terrain. Thousands of miles of multi-channel Motorola Microwave—with hundreds of operating stations—delivering non-stop, 'round-the-clock performance year in and year out.

Motorola Microwave provides simultaneous transmission of numerous (1) voice, (2) telemetering, (3) teleprinting and (4) industrial control signals over one radio frequency carrier. Microwave assures positive control of widely separated, remote system facilities. Get the facts. ***Motorola Microwave can cut communications costs, save man-hours and speed operations for you!***

national Motorola® RADIO COMMUNICATIONS service

Motorola Communications & Electronics, Inc.
A SUBSIDIARY OF MOTOROLA, INC.
4501 W. Augusta, Chicago 51, Ill. • Rogers Majestic Electronics Ltd., Toronto, Canada

Motorola Systems Are In and Working for These Companies

Partial list of systems installed and operating.

Arkansas Power and Light Company*
Bonneville Power Administration
Brazos River Electric Transmission Cooperative
Central Illinois Public Service Company
Cleveland Electric Illuminating Company*
Dayton Power and Light Company
Gulf States Utilities Company*
Illinois Power Company
Louisiana Power and Light Company*
Mississippi Power and Light Company*
New Orleans Public Service, Inc.*
Northern Indiana Public Service Company*
Ohio Power Company*
Pacific Power and Light Company
San Antonio Public Service Board
Southern California Edison Company
Texas Electric Company

*Under Construction

Job-Proven Microwave . . . by the Leaders of the 2-way Radio Industry